ON Semiconductor

Design Note – DN05037/D

Extremely Low Power Off-line Supply

Device	Application	Input Voltage	Output Power	Topology	I/O Isolation
NCP1050	Sensors	90 - 300 Vac	15 mW	Flyback	None

Other Specifications

Output Voltage	5 Vdc
Nominal Current	3 mA
Input Consumption	<0.5 mArms

Introduction

There are many power solutions that comply with the Energy Star directives for stand-by / no load consumption. Most of them rely on converters that switch in bursts or get into skipping mode.

The NCP1050 is a good candidate for such applications and this design note describes a simple off-line power supply that operates at a very low power consumption. It is used to power up a motion / infrared sensor and the logic circuit associated with it. This supply provides 15 mW output power while consuming only 0.5 mA from the AC line in order not to trip the GFCI protection.

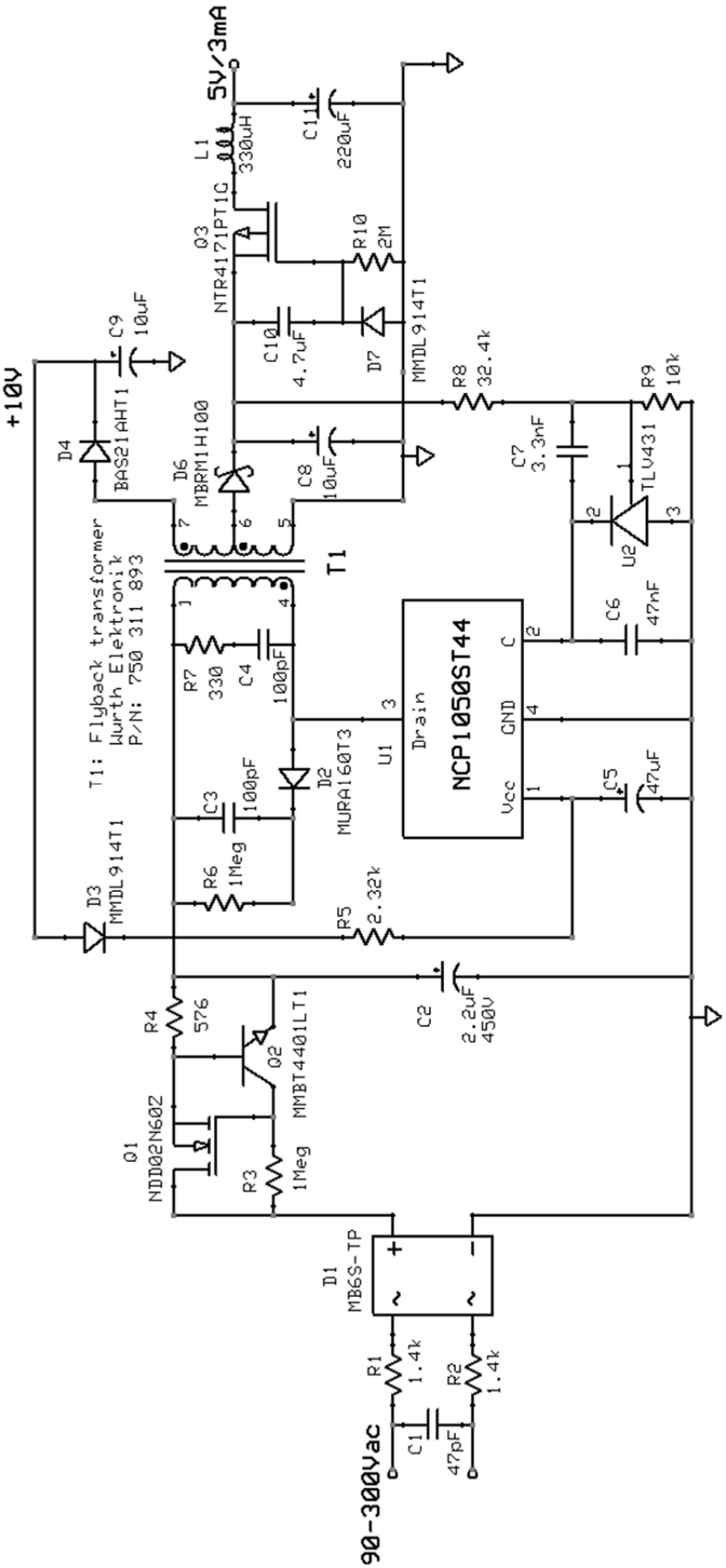
Circuit Description

The NCP105X family of gated oscillator type converters is very suitable for this application. In order to minimize losses the NCP1050 is chosen because it has the lowest peak current level in the family and provides 44 kHz operation.

The circuit is a typical flyback and since no isolation is required it is pretty simple. The secondary has basically two windings: one provides the main output (5 V) and the other one provides the bias (10 V) for the NCP1050. Although the NCP1050 can be self biased, using an extra winding for bias results in even lower power consumption.

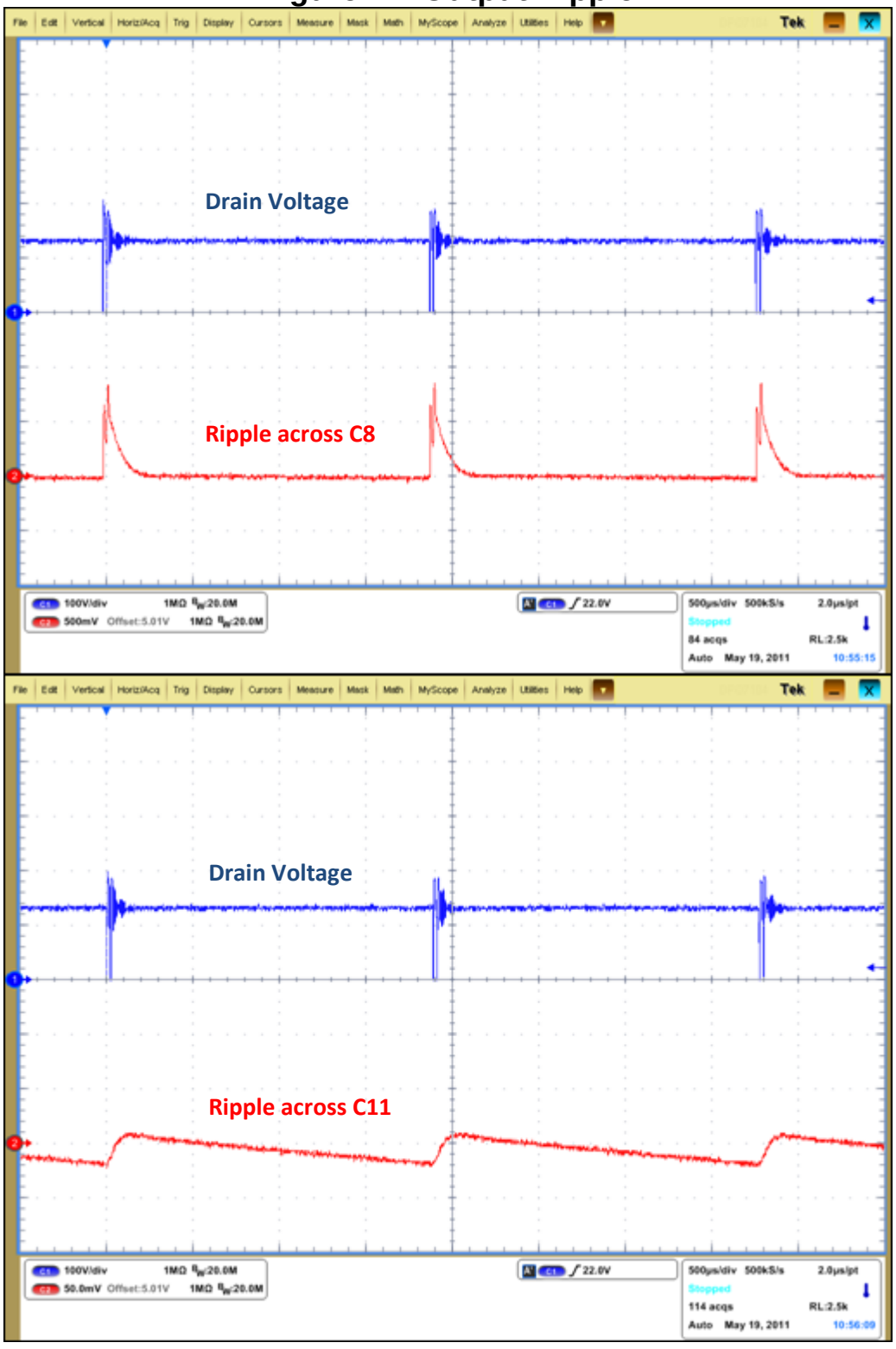
The input filtering capacitor (C2) needs to have a very low value in order to minimize the rms input current. A 2.2 uF value works very well. To reduce even more the current spikes due to the input capacitor being charged each cycle, a current limiter (Q1 – Q2) is also added. With all these precautions the converter produces 5 V / 3 mA output while consuming 0.49 mA at 110 Vac while maintaining the inrush current below 2 mA. Input power at 110 Vac input was 51 mW (measured with Yokogawa WT210 power meter and averaged over a 2 minute period).

Figure 1 - Schematic


5V/3mA
+10V
90-300Vac
NCP1050ST44
Drain
GND
Vcc
T1: Flyback transformer
Würth Elektronik
P/N: 750 311 893
T1
L1 330uH
Q3 NTR4171PT1G
Q2 MMBT4401LT1
Q1 NDD02N60Z
D1 MB6S-TP
D2 MURA160T3
D3 MMDL914T1
D4 BAS21AHT1
D6 MBRM1H100
D7 MMDL914T1
U1
U2 TLV431
R1 1.4k
R2 1.4k
R3 1Meg
R4 576
R5 2.32k
R6 1Meg
R7 330
R8 32.4k
R9 10k
R10 2M
C1 47pF
C2 2.2uF 450V
C3 100pF
C4 100pF
C5 47uF
C6 47nF
C7 3.3nF
C8 10uF
C9 10uF
C10 4.7uF
C11 220uF

Due to the fact that power is delivered in bursts, the output ripple is significant. Figure 2 (top) shows almost 0.8 V peak voltage ripple across capacitor C8. Beefing up C8 is not a viable option because, in this case, the input current limiter (Q1 – Q2) would prevent it from being charged and the converter will enter a hiccup mode, and will never be able to fully start. Therefore a series transistor (Q3) is added after C8 to act like a soft start and slowly charge a larger capacitor C11. This way, voltage ripple across C11 is reduced bellow 50 mV peak-to-peak - figure 2 (bottom)

Figure 2 – Output Ripple



Resistors R1 – R2, in front of the bridge, also help reduce current spikes and, in conjunction with capacitor C1, act like an input EMI filter. The EMI scans in figure 3 show the circuit passes Class B requirements.

Figure 3 – EMI Scans

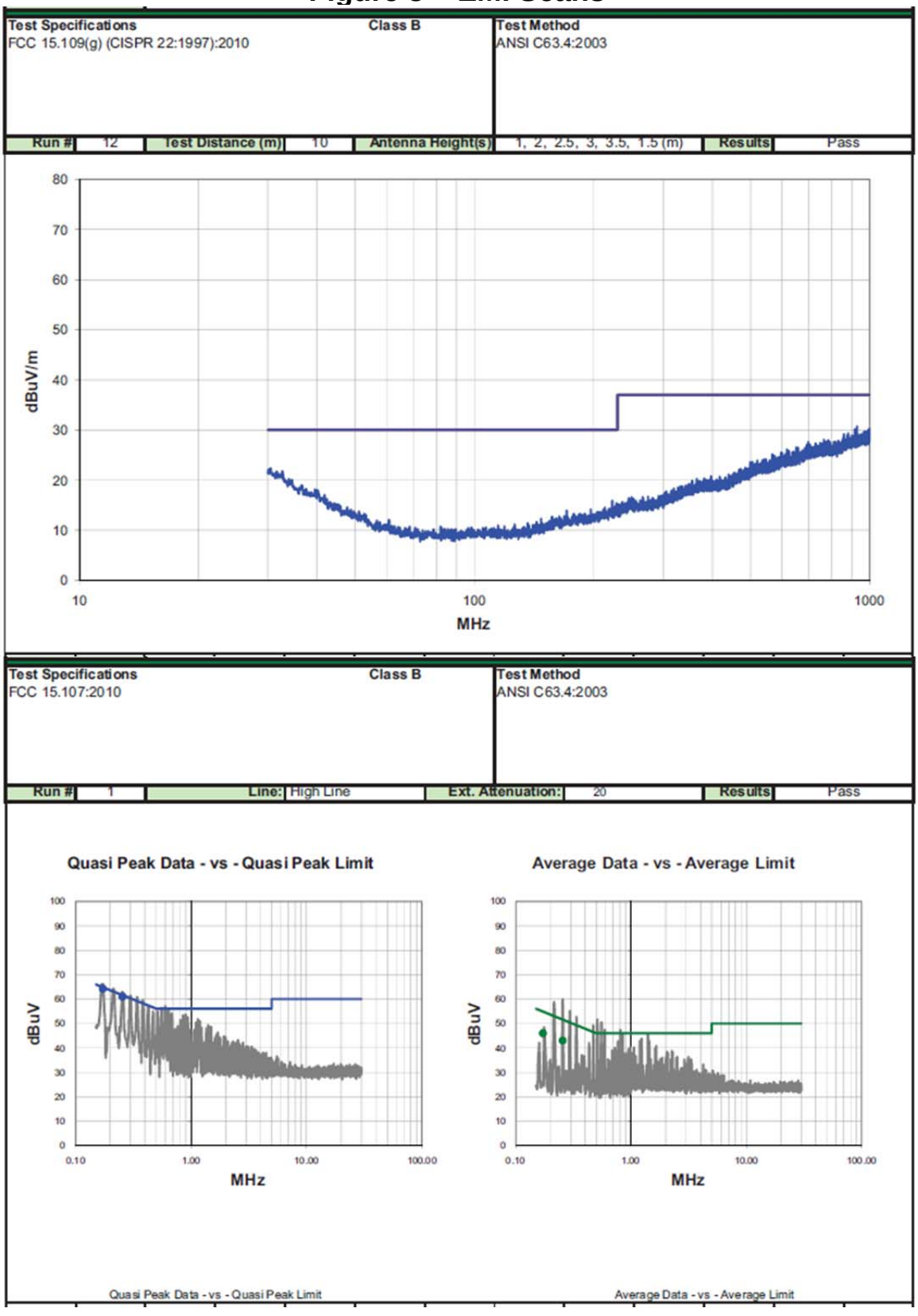


Figure 4 – Input current at 110 Vac input

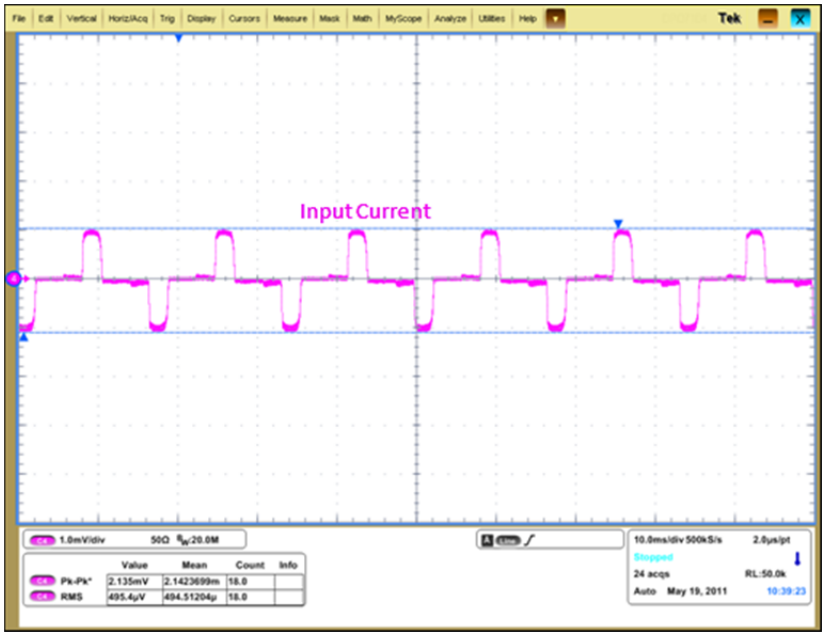
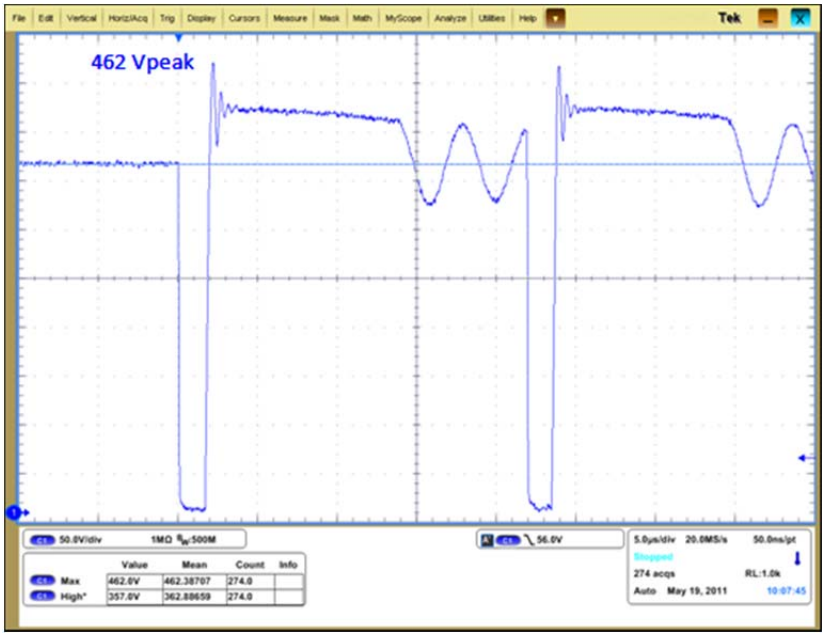
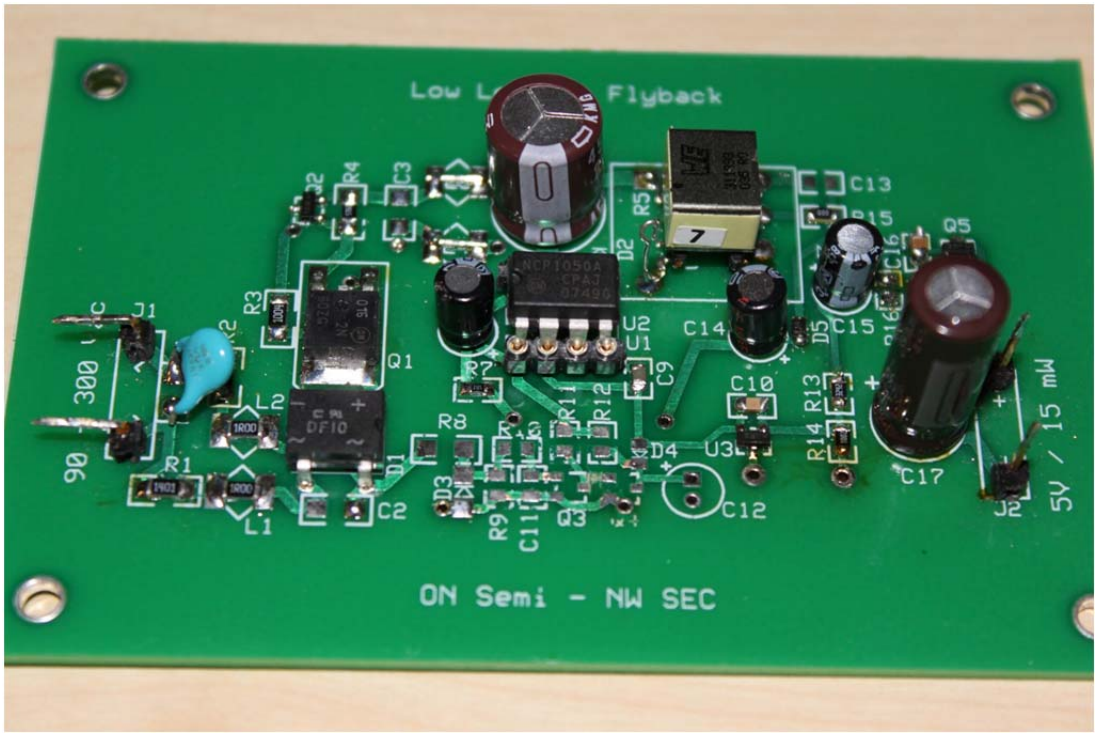


Figure 5 - Maximum drain voltage at 300 Vac input



Board



Key Features

- Simple topology
- Low part count
- Extremely low consumption
- Wide input range

References

Data sheet NCP1050: Monolithic High Voltage Gated Oscillator Power Switching Regulator

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